Interactions between wheat gluten, water, and ethanol contributing to separability during ethanol washing.

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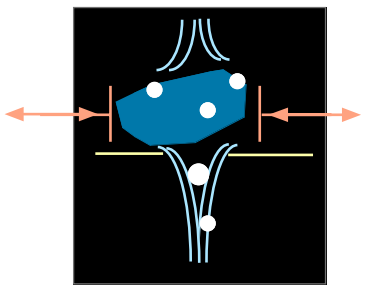
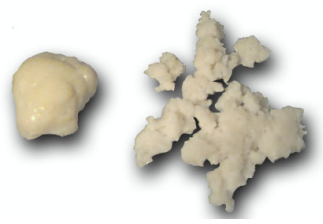
The purpose of the research program represented here is to identify factors leading to improved separation during separation-directed washing of wheat dough. The goal was to minimize applied energy and capital cost for this separation.

The opportunity related to this report is a WRRC-developed separation process that applies cold ethanol to the washing separation of wheat dough into starch and protein concentrates. During washing, the dough is manipulated and the starch is very quickly washed away leaving a protein-rich gluten concentrate (Fig 1). The processing advantages that could materialize from this research include lower capital cost for washing, lower capital cost and reduced energy during drying (product properties and displacement drying (Fig 2)), and improved starch separation (greater density difference between starch and fluid). The complete process involves hydration, dough development, resting and washing.

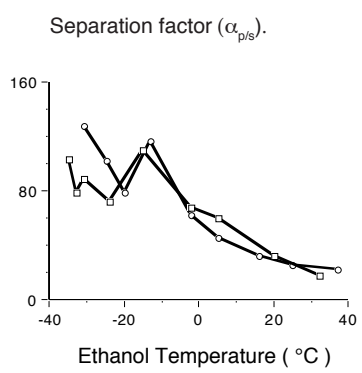


1. Cartoon of separation process. Shown are gluten (blue), washing fluid (light blue), starch (white), supporting screen (yellow), and manipulation (orange).

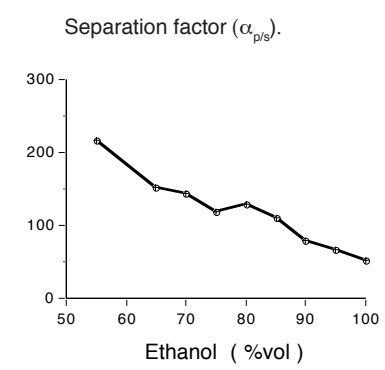


2. Gluten produced by washing in water (left) and by washing with refrigerated ethanol (right). The curdlike, spongy texture of the ethanol-washed gluten presents processing advantages.

The problem. The completeness of the separation during washing (as indicated by a large separation factor (ratio of protein-to-non-protein in gluten fraction divided by the same ratio in the starch fraction) was improved by low temperature (Fig 3) and intermediate water content of the washing fluid (Fig 4). (*Robertson and Cao, "Substitution of concentrated ethanol for water in the laboratory washing fractionation of protein and starch from hydrated wheat flour." Cereal Chemistry 74(4):508-513,1998*). The temperature dependence of the separation was expected based on previously reported, but limited, gluten dissolution data and physical reasoning, but the efficacy of wet ethanol contradicted expectation since pure water washing produces a lower separation factor (<100) using standard conditions at the same 80s time. Differential swelling of gluten in aqueous ethanol was examined here as one possible contributing factor to the success of this size-based separation process.

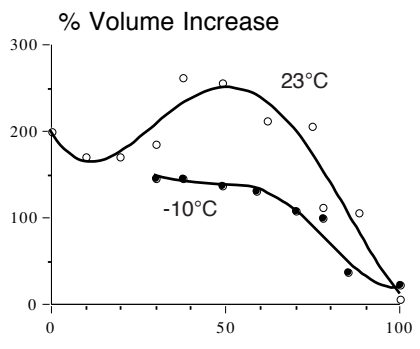


3. Separation improves at low temperature.

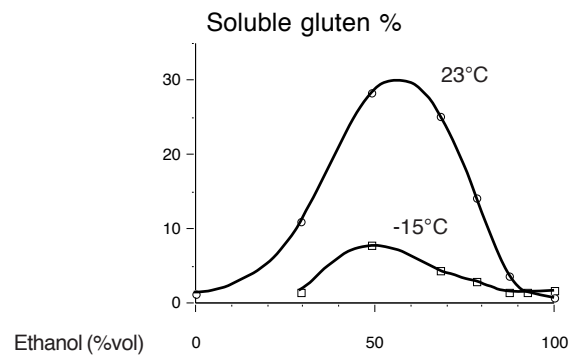


4. Separation improves with added water.

Dissolution and settled-volume data (standard laboratory methods) revealed an unexpected result. This was a maximum settled volume (Fig. 5) which corresponds to the maximum dissolution of gluten (Fig 6) and the concentration for best separation (Fig 4). This observation confirms a possible protein-matrix swelling contribution to separation. Further, although a lower temperature reduced the extent of the swelling (and dissolution) there was still a substantial concentration-dependent swelling effect. Settled volume was equivalent to mass uptake measurement and both were reduced by centrifugation at greater than 1xg suggesting fragility of the swollen matrix. We also found no selectivity in the uptake of the solvent by gluten.

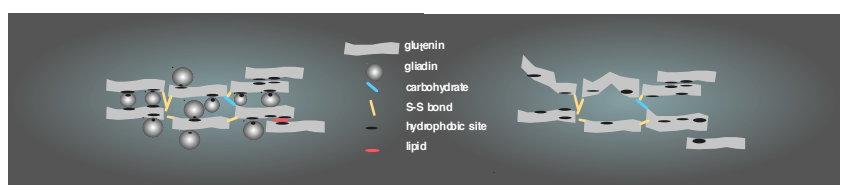


5. Settled volume maximum corresponds to dissolution maximum.



6. Relative dissolution of gluten depends strongly on the solution concentration.

Gliadin-class proteins are classically defined by their solubility in 70% ethanol. By reference to the model shown in Fig 7. (after *Weegels and Hamer, Cereal Foods World 37:379-385(1992)*), the gliadins provide cross-links between the longer and more linear glutenins. The action of aqueous ethanol solutions is to remove these as well as some of the lipids. Their absence and the data here suggest that the resulting glutenin enriched matrix is more flexible and can accommodate more absorbed solvent; hence, greater settled volume. The higher surface tension of water-rich solutions may also contribute to reduced matrix swelling.



7. Low temperature and low water concentration supports model at left. Intermediate water concentration and high temperature supports model at right

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